Self-Healing Corrosion Protection by Phosphate-Doped Enamel Coatings on Steel in Simulated Cement Pore Fluid
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ABSTRACT
Phosphate was incorporated into enamel coatings by doping sodium borosilicate glasses with 7 mol% P2O5. Corrosion resistance of phosphate-doped (7P) and base enamels (0P) in simulated cement pore fluid (Lawrence solution) was evaluated, with the focus of studying the effect of artificial damage on the protection property of the coating. It reveals that after three days immersion in Lawrence solution (LS) 7P coating developed a precipitate layer on the defect, whereas 0P shows initialization of pitting corrosion in the exposed substrate at the defect. The precipitate layer was characterized by Micro-Raman and X-ray diffraction, suggesting formation of hydroxyapatite. Linear polarization of damaged coatings shows active corrosion for 0P through all immersed times. However, there is a passivation gradually developed for 7P coatings with increasing immersion time. Electrochemical impedance spectroscopy was also used to study the corrosion resistance of damaged coating. By equivalent circuit simulation, it reveals that the charge transfer resistance of 7P coating increased as a function of immersion time and is two orders of magnitude higher than 0P coating after three day immersion. It suggests that 7P coating exhibit active corrosion protection, which is not only protect the substrate with a nonconductive barrier but provide continued protection to the exposed substrate after partial damage of the coating. The self-healing property is believed to be attributed to the Ca-P precipitates which impede the movement of electrolyte and corrosive species, slowing the corrosion rate.